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Battocletti Collection

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Biographical/Background Note: Dr. Joseph H. Battocletti was Professor Emeritus of Neurosurgery at the Medical College of Wisconsin and a Biomedical Engineer at the Zablocki VA Medical Center, where he still worked part time almost daily until his death in 2013, at the age of 87. Dr. Battocletti taught electrical engineering at Loyola University of Los Angeles and was an Adjunct Professor of Biomedical Engineering and Electrical Engineering at Marquette University before joining the Medical College of Wisconsin as a research associate in 1970. His research included blood flow measurement using nuclear magnetic resonance (NMR, known more commonly now as MRI), transcutaneous electromagnetic techniques, and magnetic stimulation of peripheral nerves in the arm and of nerves in the head.

Accurate, non-invasive blood flow measurement had long been a goal of medical researchers when Dr. Battocletti began his work in the early 1970s at the Medical College of Wisconsin. Research for the application of nuclear magnetic resonance (NMR) principles to the noninvasive measurement of blood flow in humans began at the National Heart, Lung, and Blood Institute (NHLBI) in 1956, and continued in university laboratories. Doctors knew that non-invasive measurement of blood flow in the limb, and especially the leg, where most vascular diseases occurred, would facilitate early detection of such diseases. Such early detection would enable diagnosis and treatment of the disease before limb amputation would be necessary. As detailed in the paper "The NMR Blood Flowmeter, Theory and History" by Joseph H. Battocletti, Richard E. Halbach, Sergio X. Salles-Cunha, and Anthony Sances, Jr., published in the July/August 1981 issue of *Medical Physics*, Vol. 8(4) at pages 435-443, following the

discovery of the phenomenon of nuclear magnetic resonance, scientists began experimenting to determine if liquid flow could be measured non-invasively using the principles of nuclear magnetic resonance (NMR). It was soon discovered that the nuclear magnetic response signal induced in a moving, paramagnetic fluid was low when fluid velocity was low, due to saturation in the detector, but the NMR signal magnitude increased in response to an increase in fluid velocity as a consequence of magnetized nuclei entering the detector from upstream of the saturation region.

As described in the patent for an NMR blood flowmeter invented by Battocletti (U.S. Patent No. 4613818), blood flow in human limbs could be measured non-invasively by a nuclear magnetic resonance flowmeter which included a pair of polarizing magnets whose fields were stabilized by electromagnets in each pole piece, that were in turn energized in accordance with the magnetic flux of the magnets regulated by a special sensor. Battocletti's invention represented an improved NMR blood flowmeter which accomplished two dimensional imaging of blood flow so as to enable noninvasive arterial or venous blood flow measurement above a particular baseline and allowed blood flow measurement with a vein or artery along a base line to the exclusion of all other arteries or veins.

Series/Scope and Content Note: This collection consists primarily of material related to a superconducting magnet, developed at the Medical College of Wisconsin in the 1970s and housed in the National Museum of Health and Medicine's historical collection. Research on blood flow measurement using nuclear magnetic resonance (NMR) techniques began at the Medical College of Wisconsin in 1970 and a superconducting magnet was eventually built in cooperation with the Intermagnetics General Corporation (IGC) in 1978 for the Biophysics Laboratory, where Dr. Joseph Battocletti conducted his research on blood flowmeters. Additional materials in this collection document the operation of a helium liquefier used in Dr. Battocletti's research. Materials include articles on the development of NMR blood flowmeters, correspondence, catalogs, manuals, newsletters, blueprints, and a laboratory notebook.

BOX AND CONTENT LIST

Box 001:

00001: Articles on Nuclear Magnetic Resonance Blood Flowmeters (1981-1986)

- Joseph H. Battocletti, et al. "The NMR blood flowmeter—theory and history," *Med. Phys.* 8 (July/August 1981): 435-443.
- Richard E. Halbech, Joseph H. Battocletti, et al. "The NMR blood flowmeter—design," *Med. Phys.* 8 (July/August 1981): 444-451.
- Sergio X. Salles-Cunha, Richard E. Halbech, Joseph H. Battocletti, and Anthony Sances, Jr. "The NMR blood flowmeter—applications," *Med. Phys.* 8 (July/August 1981): 452-458.

- Joseph H. Battocletti, "Blood Flow Measurement by NMR," *CRC Critical Reviews in Biomedical Engineering* 13 (1986): 311-367.

00002: Correspondence, Garry Morrow of IGC to Dr. Battocletti, Proposed Cryomagnetic System for Blood Flow Studies (1973)

00003: Correspondence re: Design and Operation (1973-1978)

00004: IGC Newsletter and Specs (1974-1978)

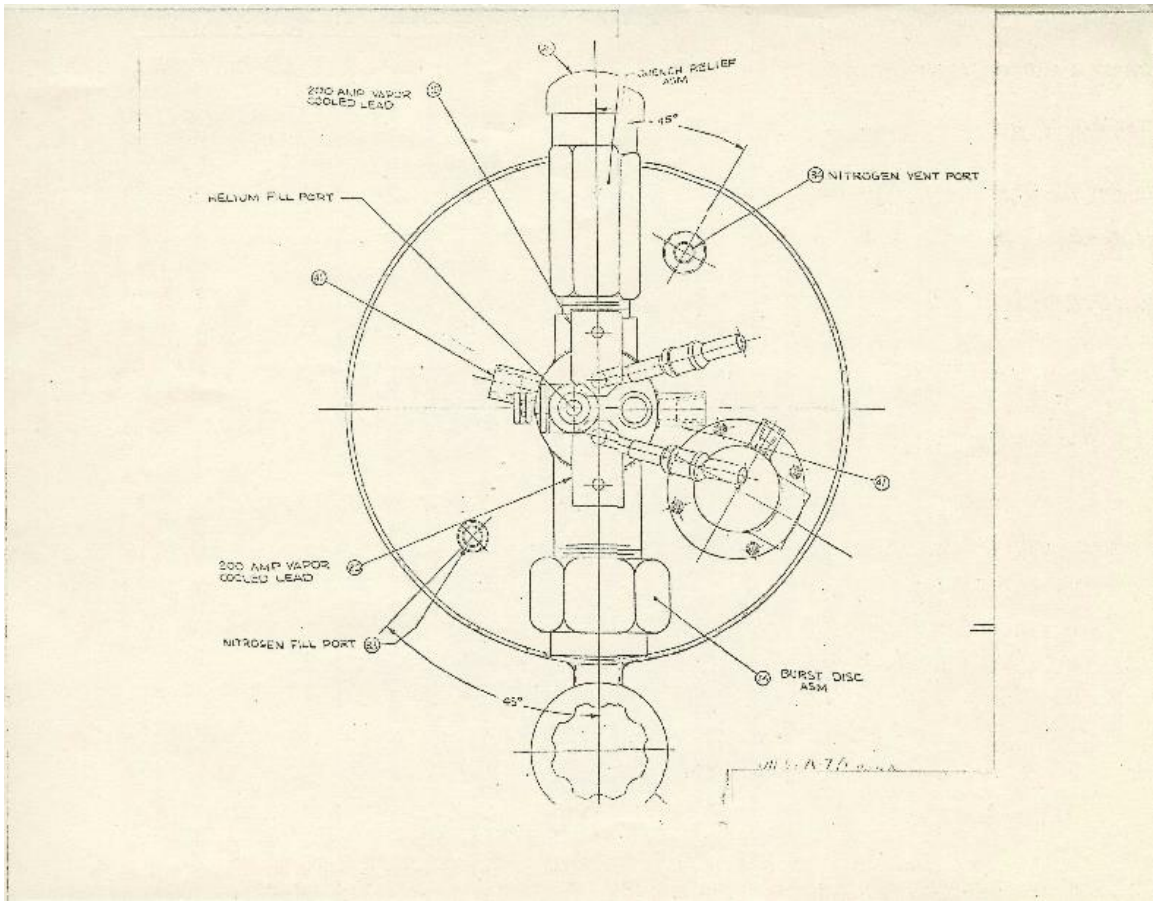
00005: Report on Visit to Intermagnetic General Corp. on Progress of Superconducting Magnet (11/8/76)

00006: University of Wisconsin Report, Installation of Superconducting Magnet System (7/78)

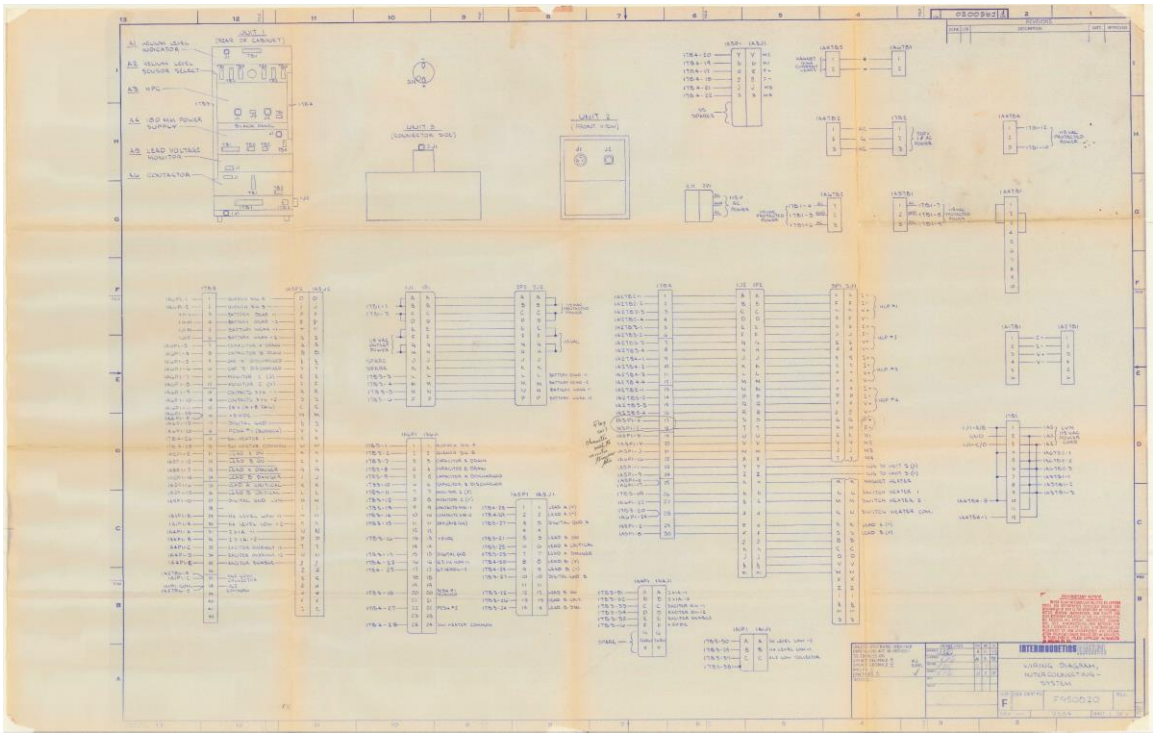
00007: MPC Interconnection Wire List

00008: Description of the 20,000 Gauss Superconducting Magnet

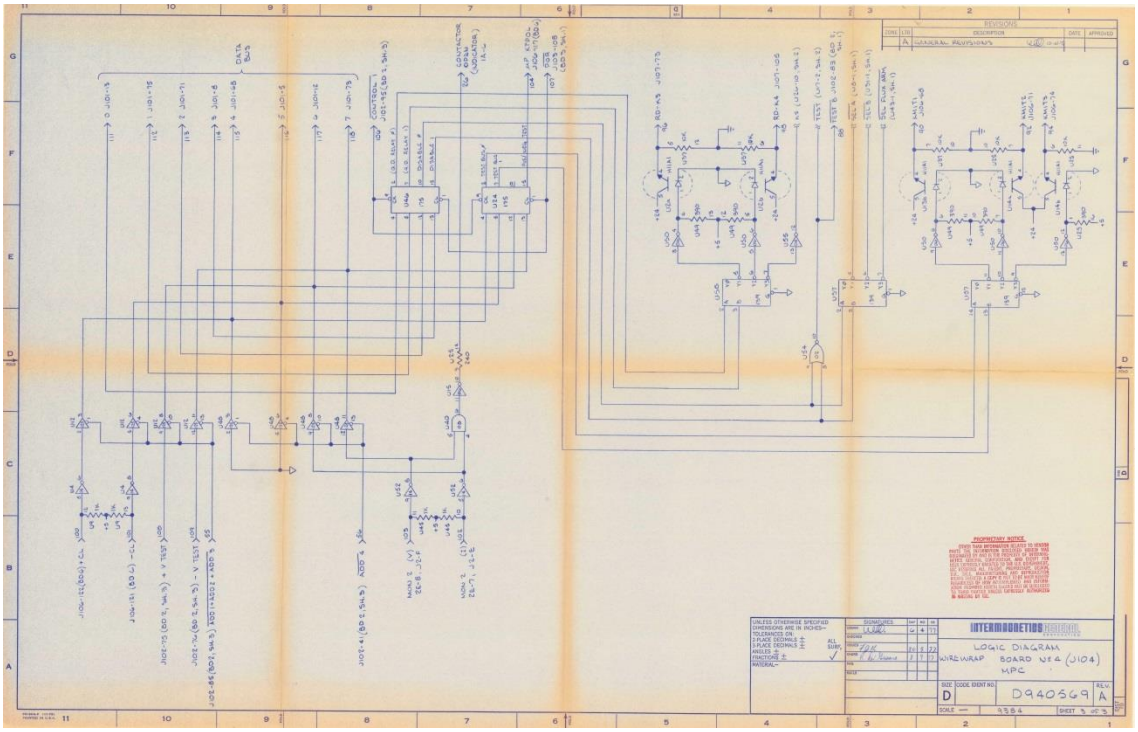
00009: Superconducting Magnet Drawings, Set 1 (sample below)



00010: Superconducting Magnet Drawings, Blueprints, Set 2 [1 of 2] (sample below)

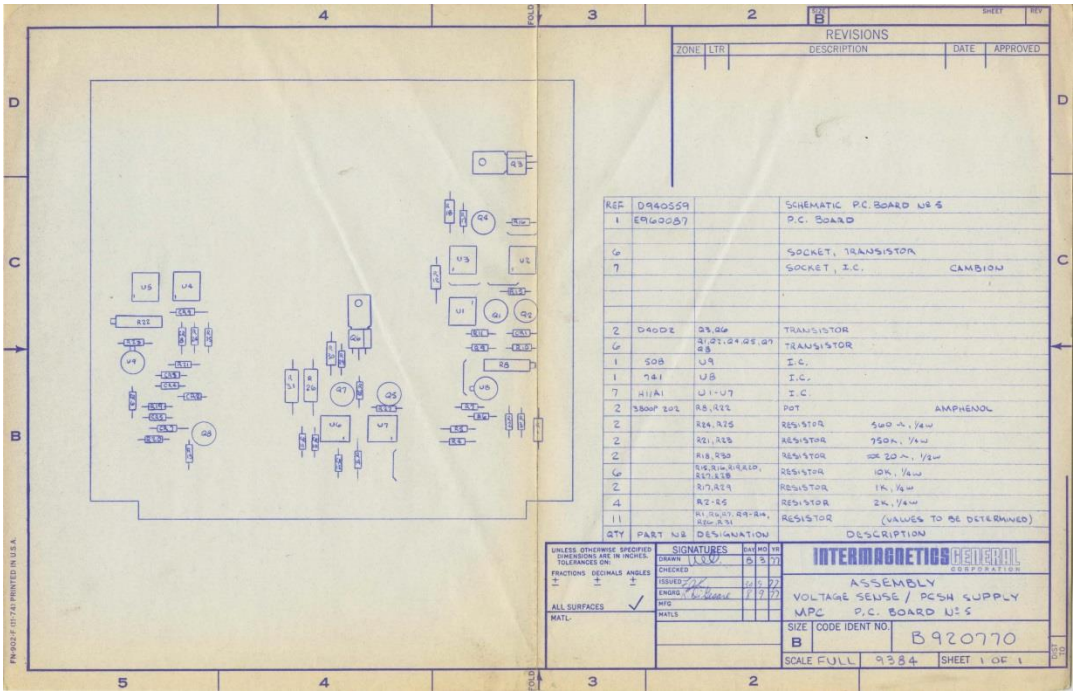


00011: Superconducting Magnet Drawings, Blueprints, Set 2 [2 of 2] (sample below)

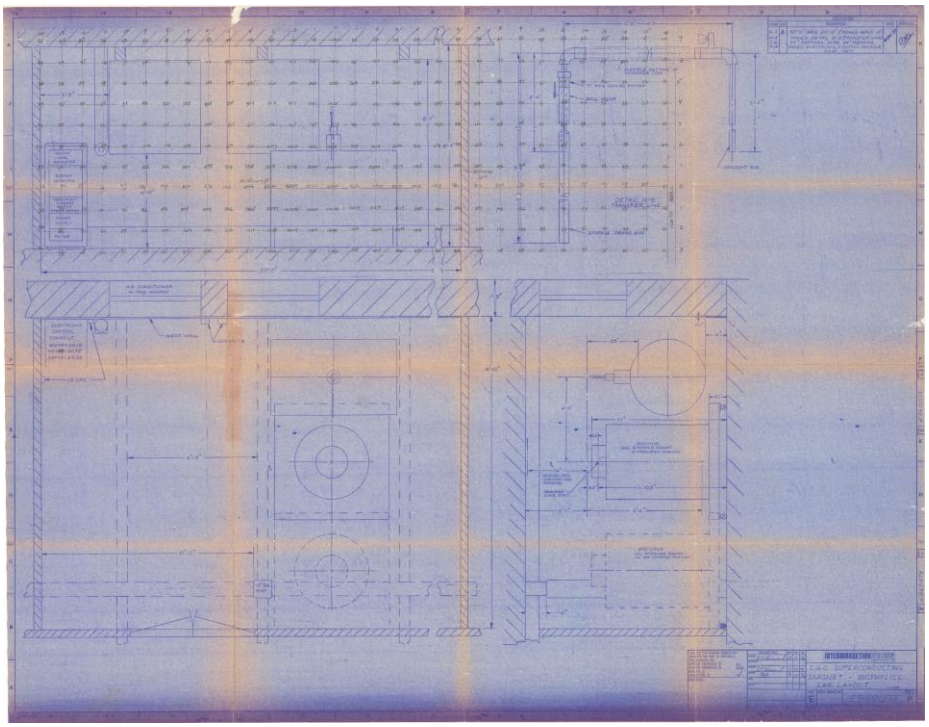


00012: Duplicate Prints and Drawings, Blueprints

00013: Magnet Drawings, Blueprints (sample below)



00014: Layout of Biophysics Laboratory, Drawing (sample below)



Box 002:

00001: Correspondence and Product Catalogs (1971)

- Superconductive Products, General Electric
- Linde Molecular Sieves, Union Carbide
- PacTec (Packaging Technologies), Division of LaFrance Corp.

00002: Wisconsin Manual, Cyromagnetic System Delivered in 1978

00003: Intermagnetics General Corp. System Operation Manual: Cryomagnetic System for Biophysics (IGC Model 9384)

00004: System Operation Manual: Cryomagnetic System for Biophysics, Appendix A

00005: System Operation Manual: Cryomagnetic System for Biophysics, Appendix B

00006: System Operation Manual: Cryomagnetic System for Biophysics, Appendix C

00007: System Operation Manual: Cryomagnetic System for Biophysics, Appendix D

00008: System Operation Manual: Cryomagnetic System for Biophysics, Appendix E

00009: System Operation Manual: Cryomagnetic System for Biophysics, Appendix F

00010: Intermagnetics General Corp., Instruction Manual for Liquid Helium Level Indicator (1971)

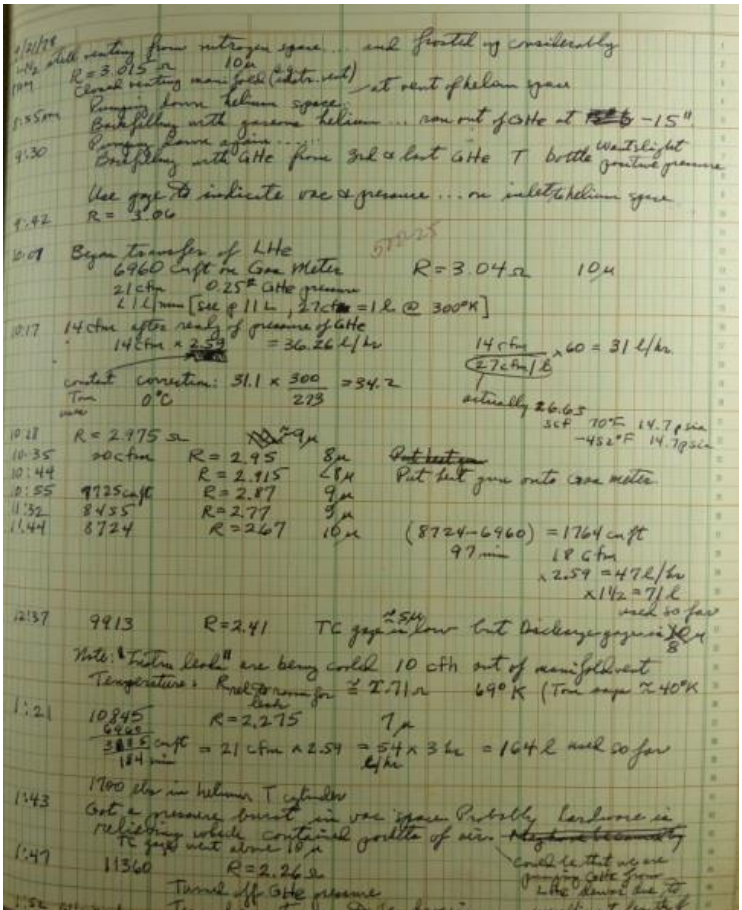
00011: Product Literature—Helium Liquefier (1973)

00012: Drawings—Helium Liquefier, Blueprints (ca. 1979)

00013: Correspondence—Helium Liquefier (1979-1984)

Box 003:

- Laboratory Notebook: Superconducting Magnet Studies
    - Includes notes, calculations, photographs, meter readings, reports, computer printouts, invoices, and correspondence (samples below)



9/21/78 Still venting from nitrogen space ... and frosted up considerably
$R = 3.015\ \Omega$ 10μ
Closed venting manifold (inlet-vent) — at vent of helium space
Pumping down helium space
9:55am Backfilling with gaseous helium ... ran out of GHe at [illegible] −15"
Pumping down again ...
9:30 Backfilling with GHe from 3rd & last GHe T bottle. Want slight positive pressure
Use gage to indicate vac & pressure ... on inlet to helium space
9:42 R = 3.06

10:01 Began transfer of LHe
6960 cu ft on Gas Meter R = 3.04 Ω 10μ
21 cfm 0.25# GHe pressure
[illegible] [see p 11 L, 27 cf = 1 ℓ @ 300°K]
10:17 14 cfm after [illegible] of pressure of GHe
14 cfm × 2.59 = 36.26 ℓ/hr
14 cfm / (27 cfm/ℓ) × 60 = 31 ℓ/hr
actually 26.65 scf 70°F 14.7 psia; −452°F 14.7 psia
[illegible] correction: 31.1 × 300/273 = 34.2
0°C

10:28 R = 2.975 Ω ~9μ
10:35 20 cfm R = 2.95 8μ Put best gas onto Gas meter
10:44 R = 2.915 <8μ
10:55 7725 cu ft R = 2.87 9μ
11:32 8455 R = 2.77 9μ
11:44 8724 R = 2.67 16μ (8724 − 6960) = 1764 cu ft
97 min 18 cfm
× 2.59 = 47 ℓ/hr
× 1½ = 71 ℓ used so far

12:37 9913 R = 2.41 TC gage ~25μ low but [illegible] gage is [illegible]
Note: "[illegible] leak" are being cooled 10 cfh out of manifold vent
Temperature: R [illegible] ≅ 1.71 Ω 69°K (T[illegible] ≈ 40°K

1:21 10845 R = 2.275 7μ
6960
3885 cu ft / 184 min = 21 cfm × 2.54 = 54 ℓ/hr × 3 hr = 164 ℓ used so far
1700 [illegible] in helium T cylinder
1:43 Got a pressure burst in vac space. Probably [illegible] is relieving which contained pockets of air. ~~[illegible]~~
TC gage went above 10μ
Could be that we are pumping GHe from LHe dewar due to [illegible] length of
1:47 11360 R = 2.26 Ω
Turned off GHe pressure
1:52 GHe [illegible] [illegible]